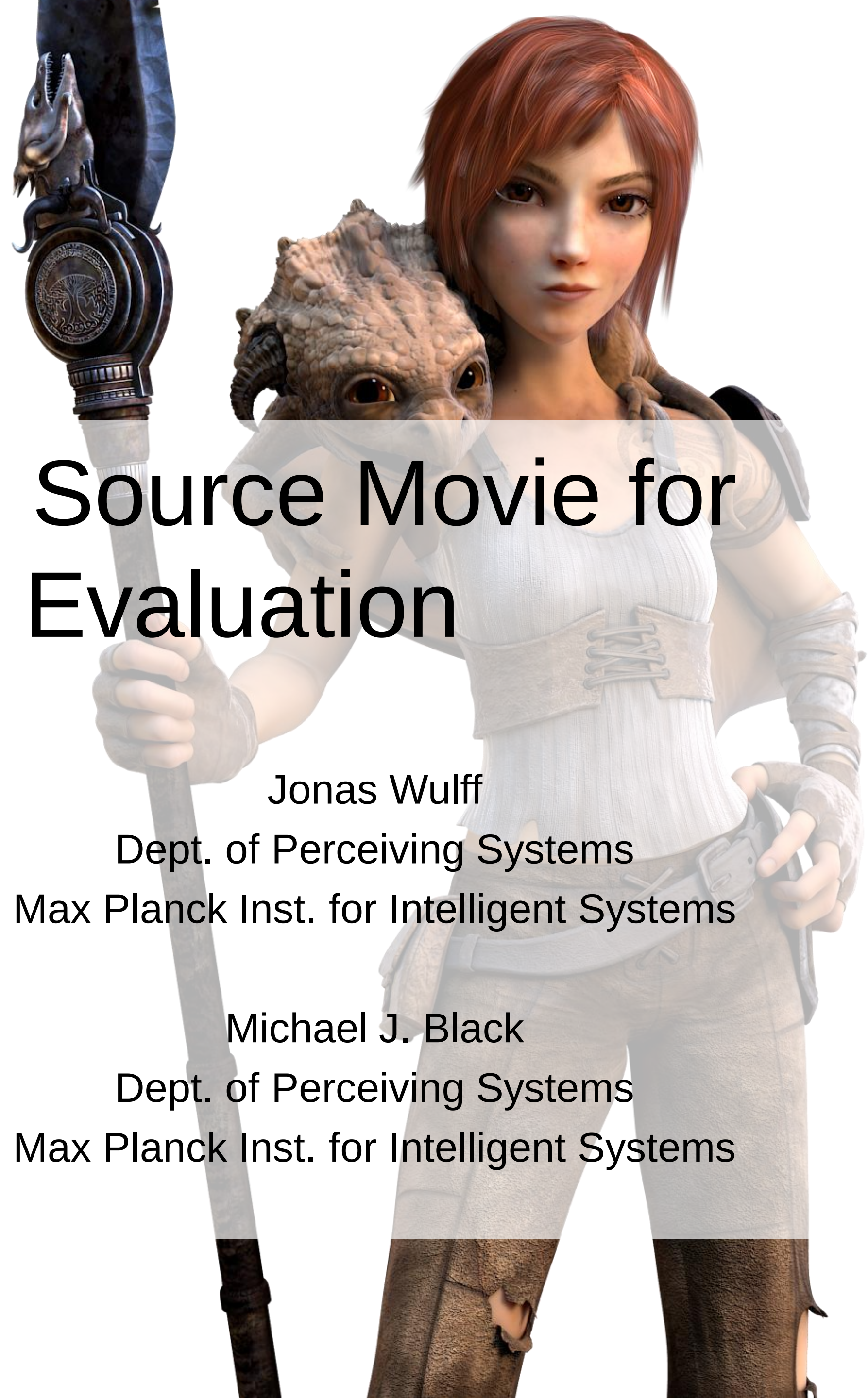


A Naturalistic Open Source Movie for Optical Flow Evaluation

Daniel J. Butler (presenting)
Dept. of Comp. Science & Engineering
University of Washington

Jonas Wulff
Dept. of Perceiving Systems
Max Planck Inst. for Intelligent Systems

Prof. Garrett B. Stanley
Dept. of Biomedical Engineering
Georgia Tech

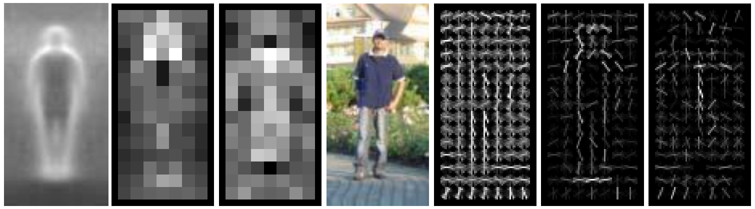
Michael J. Black
Dept. of Perceiving Systems
Max Planck Inst. for Intelligent Systems

Collaborators

Jonas Wulff
Max Planck Institute for Intelligent Systems

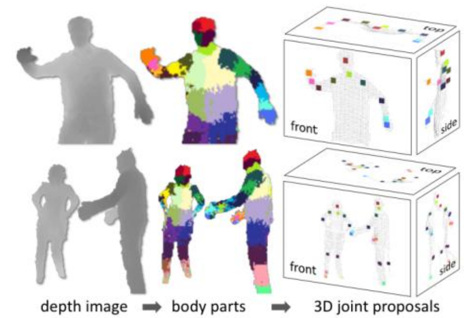
Garrett Stanley
Georgia Tech

Michael Black
Max Planck Institute for Intelligent Systems



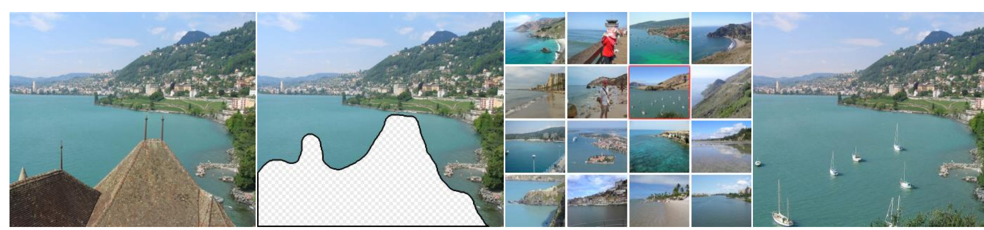
Dalal and Triggs, CVPR 2005.

Advances driven by data

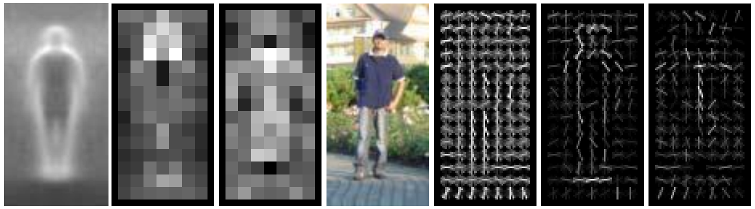


Shotton et al., CVPR 2011.

Russell, Torralba et al., IJCV 2008.



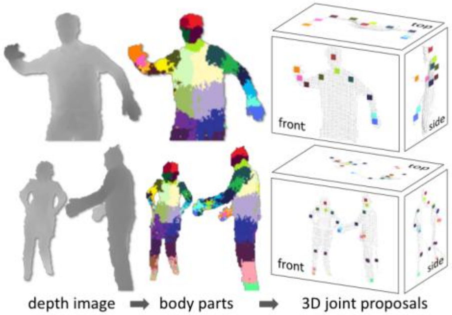
Hays and Efros, SIGGRAPH 2007.



Dalal and Triggs, CVPR 2005.

Advances driven by data

Optical flow is no different…



Shotton et al., CVPR 2011.

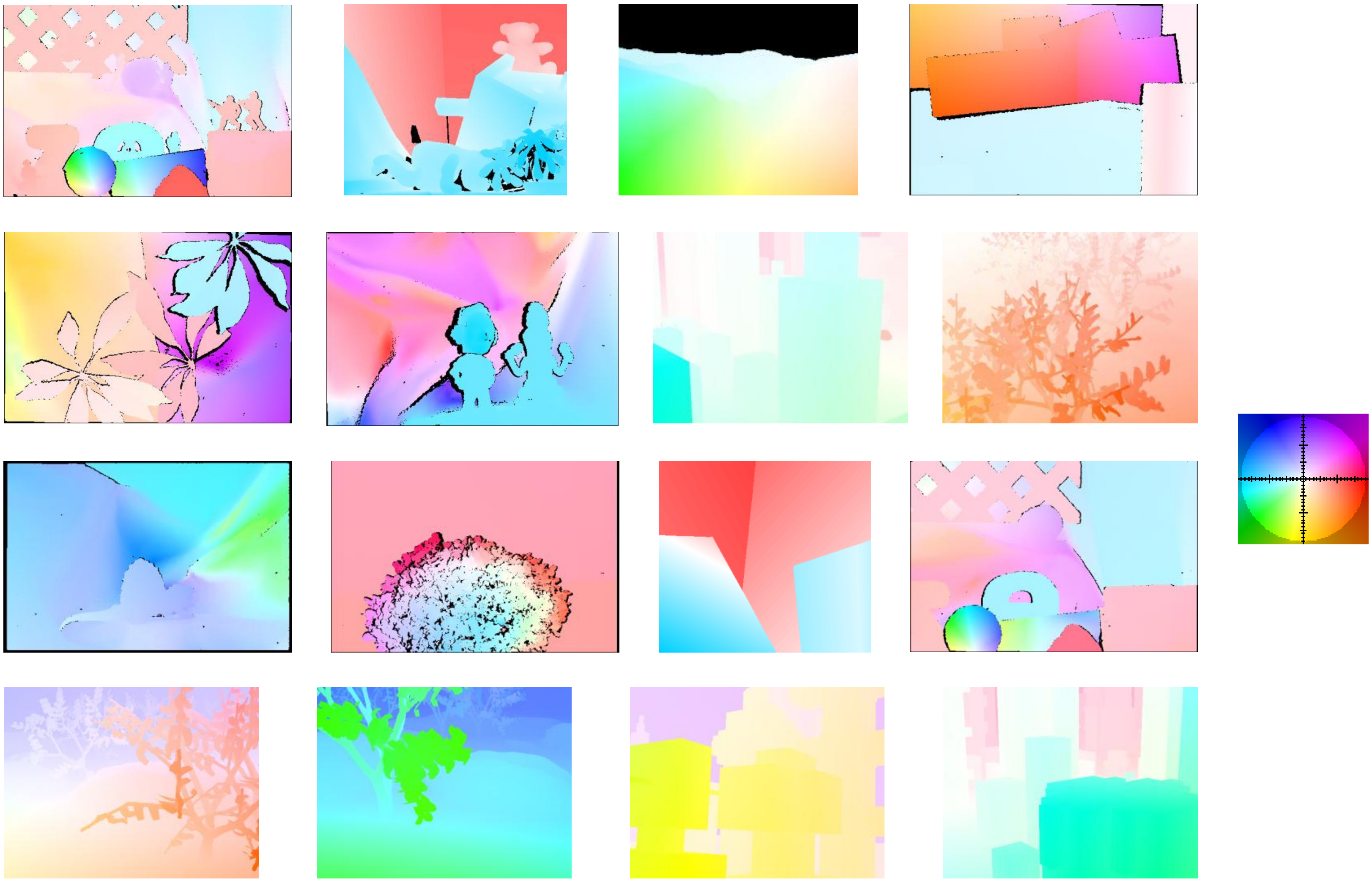
Russell, Torralba et al.,
IJCV 2008.

Hays and Efros, SIGGRAPH 2007.

Middlebury Flow Dataset (2007)

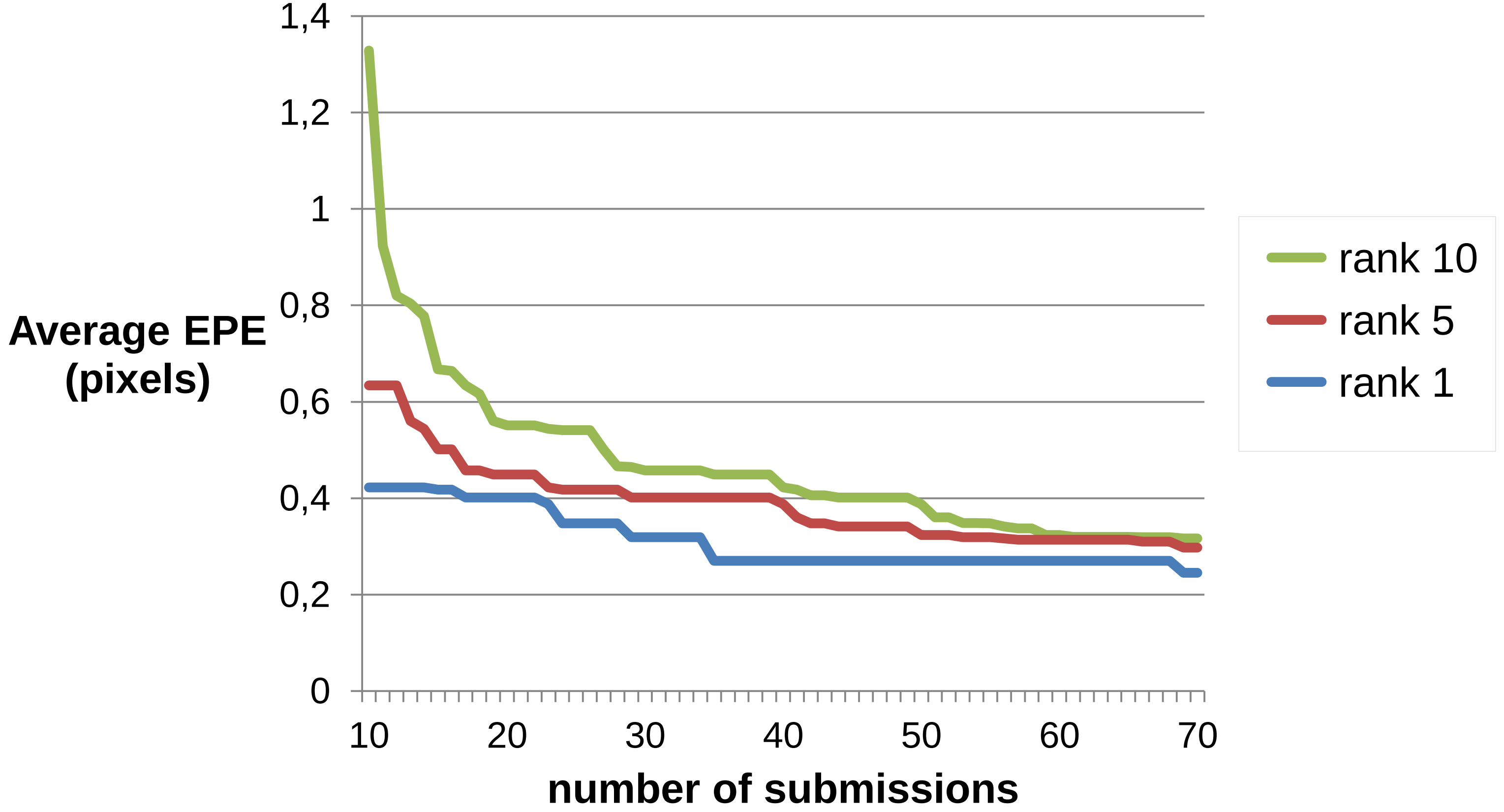
Baker et al., *IJCV* 2011.

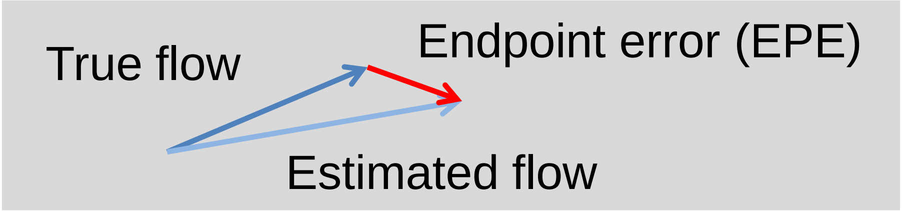
Middlebury Flow Dataset (2007)



Baker et al., *IJCV* 2011.

Error on Middlebury over time





We need a challenging new dataset

KITTI Vision Benchmark

Geiger et al., *CVPR* 2012.

Pro: real data
Con: rigid scenes

HCI Robust Vision Challenge

Meister et al., *Optical Engineering,* 2012.

Pro: real, very challenging
Con: no ground truth

UCL Ground Truth Optical Flow Dataset

Mac Aodha et al., *PAMI,* 2012.

Pro: fully controllable, extensible
Con: small, limited complexity

Human-Assisted Motion Annotation

Liu et al., *CVPR* 2008.

Pro: real data
Con: approximate ground truth

Introducing: MPI-Sintel

35 sequences, 1628 frames, 1593 flow fields

Sintel: a Blender Open Movie

Created in order to test and promote the Blender animation suite

Free and **Open**:

- All graphics data released under CC license
- Rendering software open source

Is synthetic data good enough?

Is synthetic data good enough?

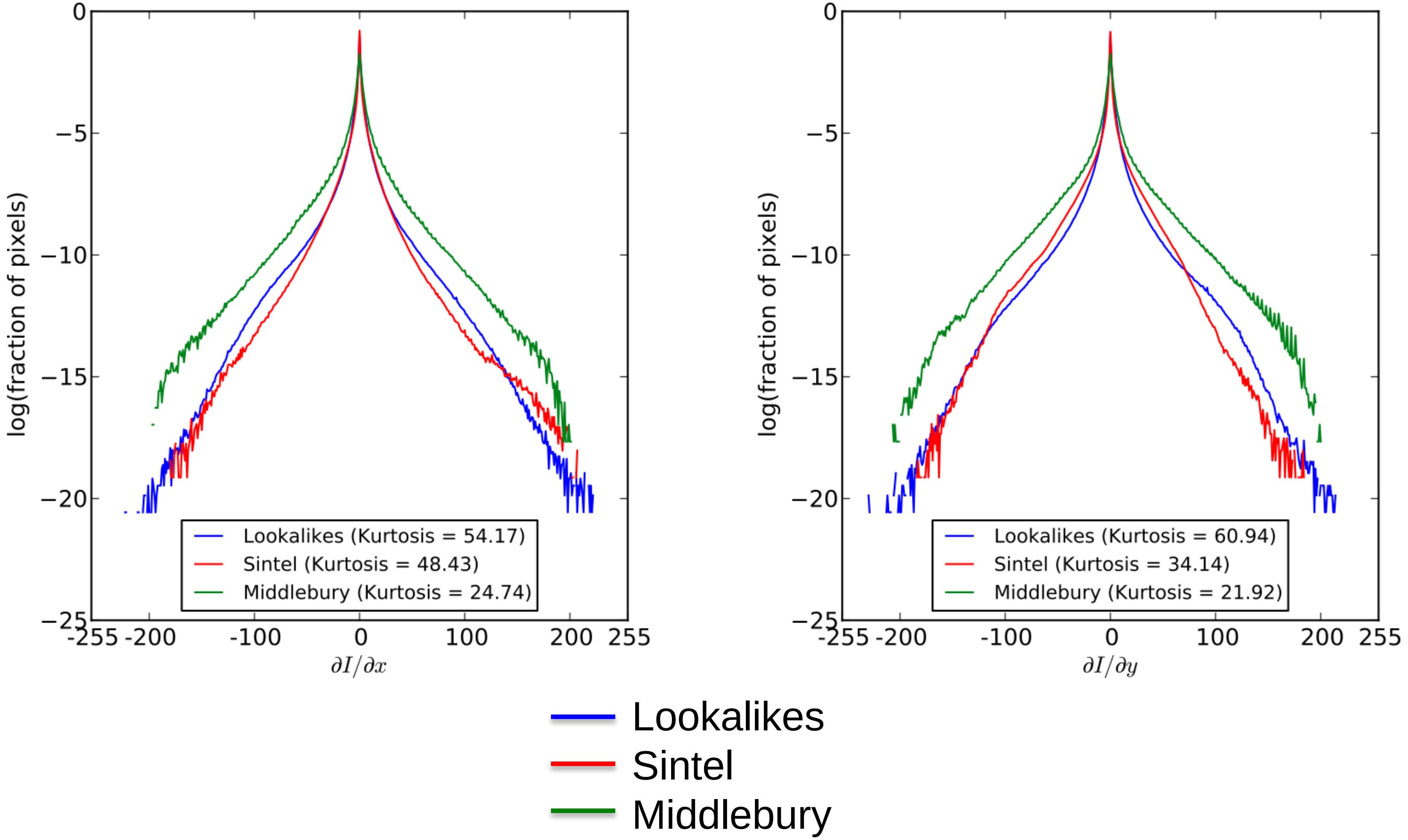
Idea: compare synthetic data to “lookalikes”

Lookalikes

Image statistics:

– Luminance histograms
– Power spectra
– Derivative histograms

Image derivative log-histograms



What about motion statistics?

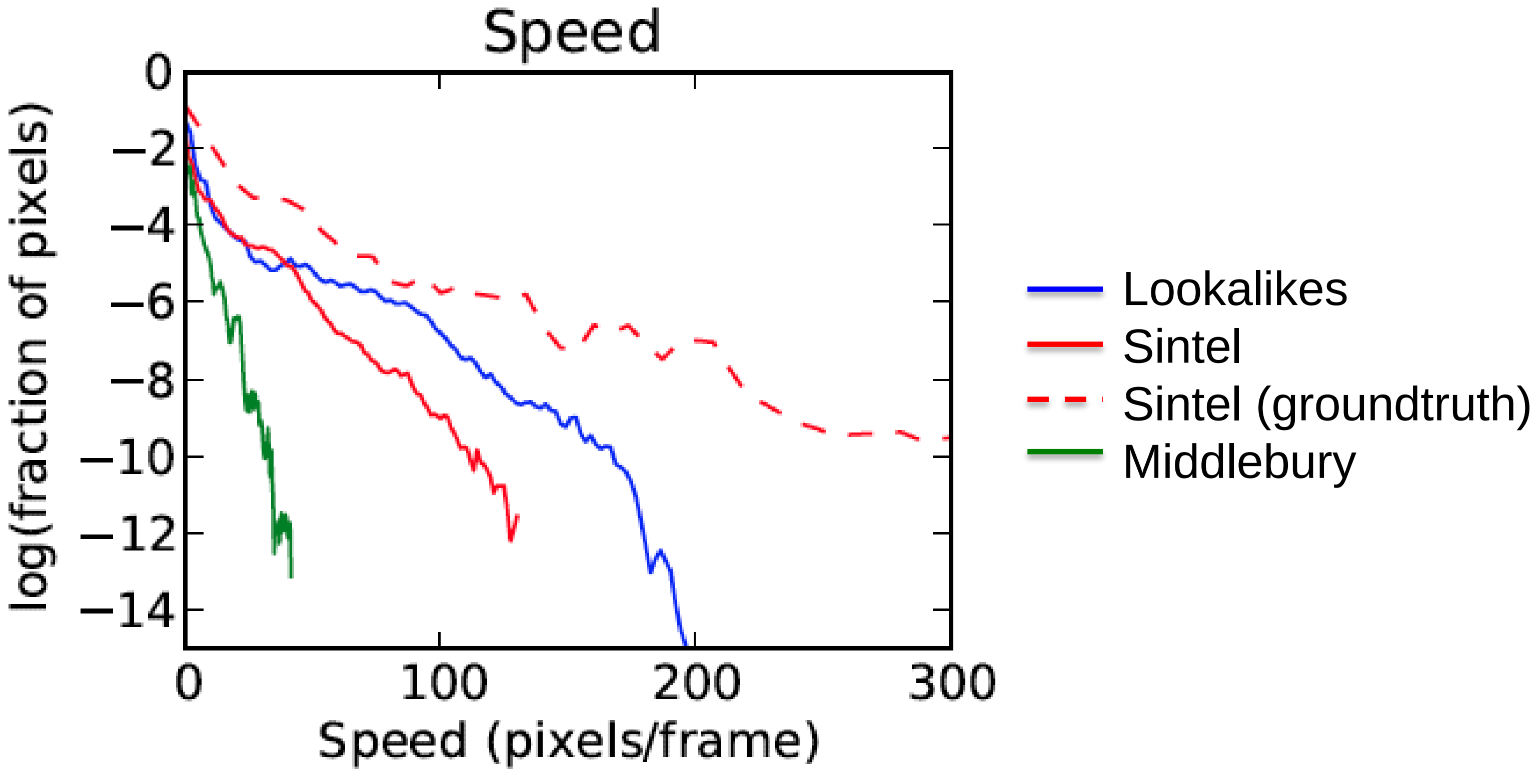
- Image statistics are only half the problem
- Do Sintel *motions* resemble *natural motions*?
  - Harder since we do not have ground truth flow for the lookalike sequences
- Approach: compare statistics of *estimated flow* on Sintel and lookalikes.

Flow statistics

(*estimated flow*):

- Histograms of horiz. and vertical components
- Speed histograms
- Derivative histograms

Speed histograms



Realism story isn’t over

- Obviously Sintel is not photorealistic
- However, it does pass some sanity checks

Future work:

1. Use photo-realistic graphics data
2. General problem of evaluating realism

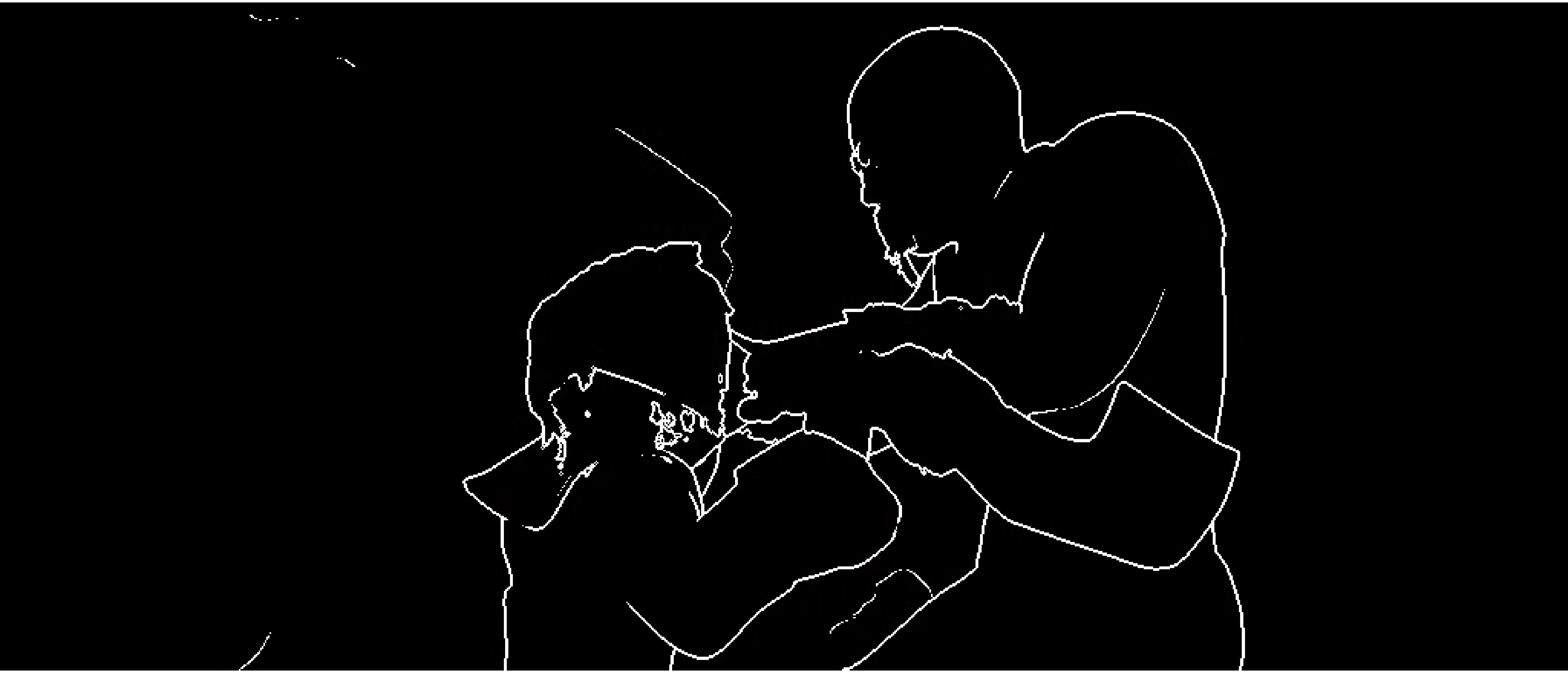
Meister and Kondermann, *Conference on Electronic Media Technology (CEMT)*, 2011.

CG data is not just “good enough”…

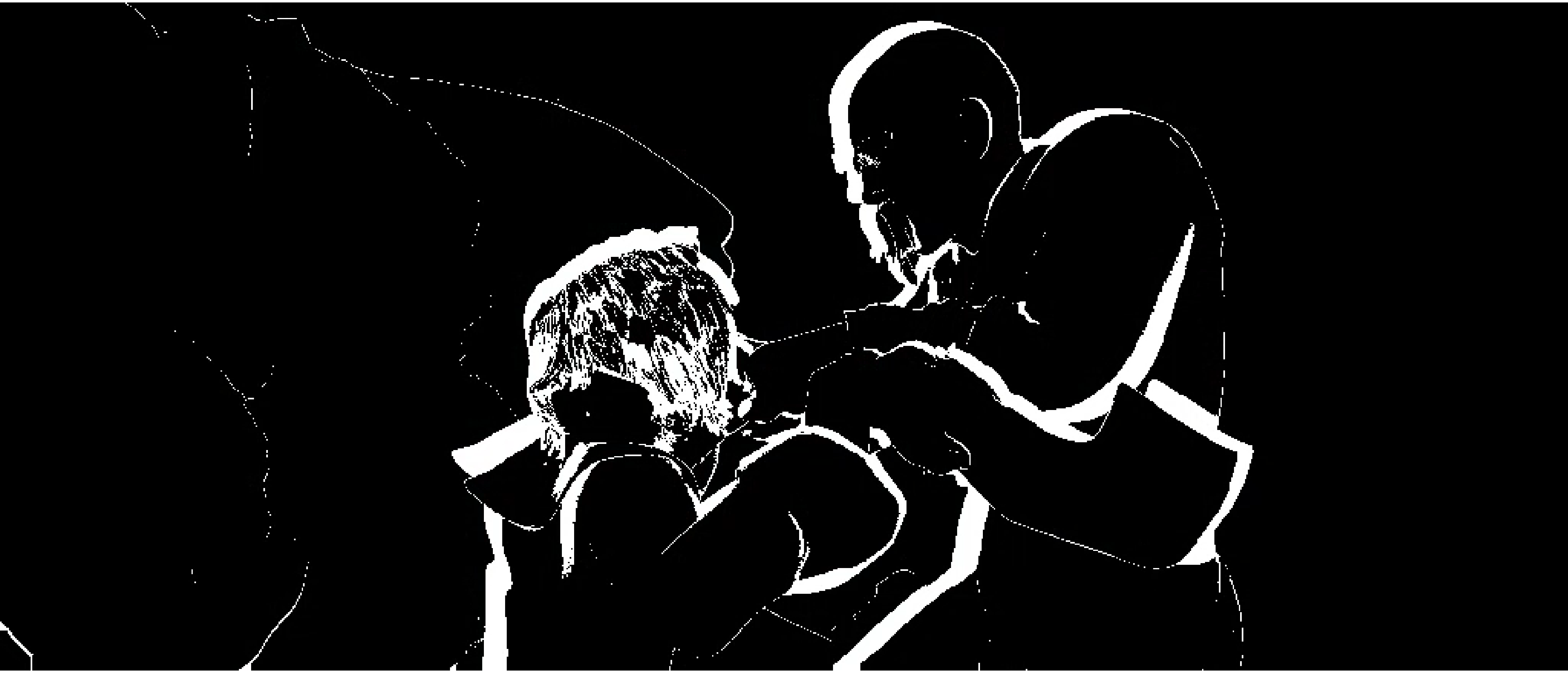
… it has major **advantages**

Render passes

high flow gradient ∩ object boundaries



Unmatched regions



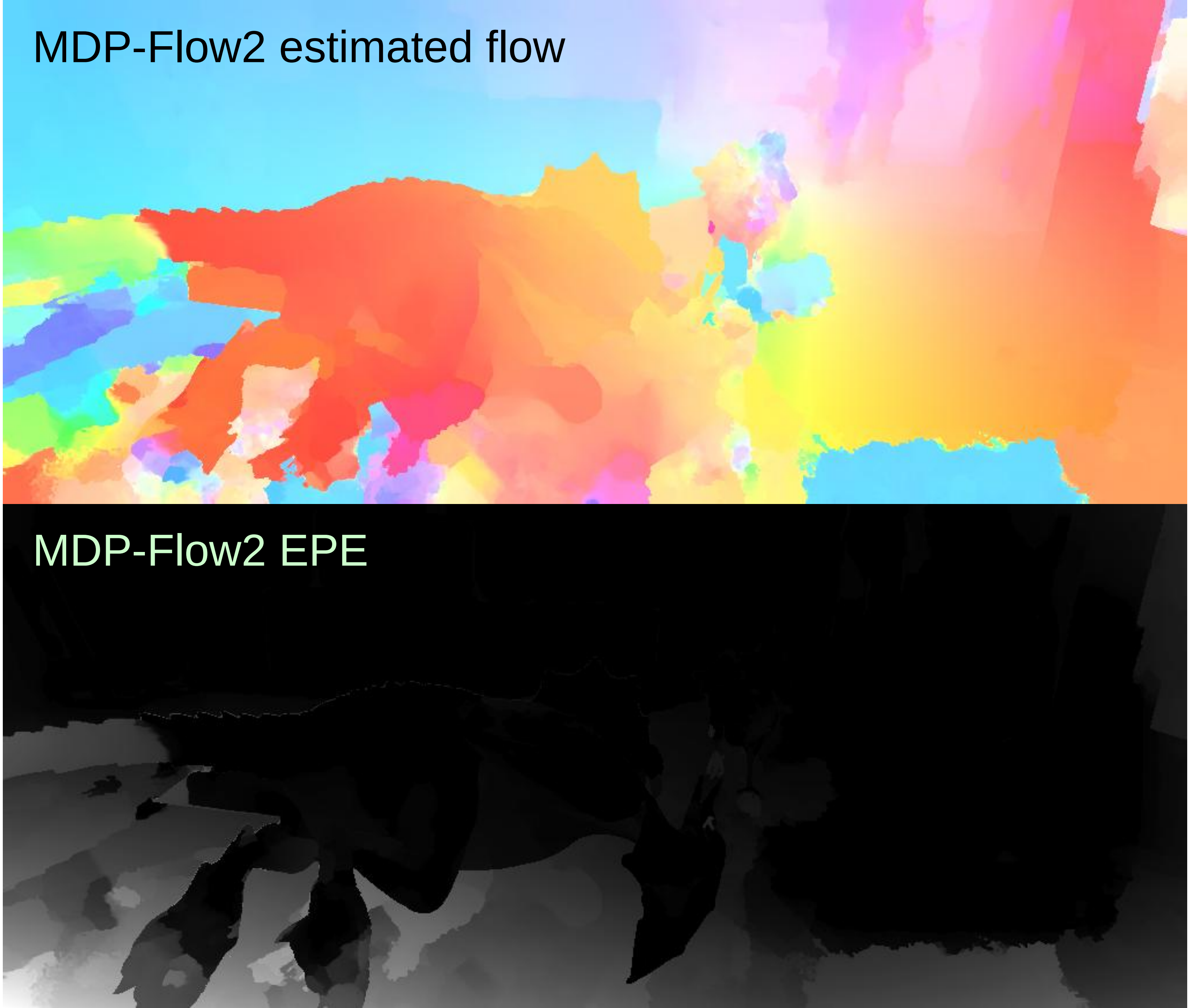
Results

http://sintel.is.tue.mpg.de

MPI Sintel Dataset | About | Downloads | Results | FAQ | Contact | Signup | Login

Final | Clean

	EPE all	EPE matched	EPE unmatched	d10-	d10-60	d60-140	s10-	s10-40	s40+	
GroundTruth [1]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Visualize Results
MDP-Flow2 [2]	8.445	4.150	43.430	5.703	3.925	3.406	1.420	5.449	50.507	Visualize Results
LDOF [3]	9.116	5.037	42.344	6.849	4.928	4.003	1.485	4.839	57.296	Visualize Results
Classic+NL [4]	9.153	4.814	44.509	7.215	4.822	3.427	1.113	4.496	60.291	Visualize Results
Horn+Schunck [5]	9.610	5.419	43.734	7.950	5.658	3.976	1.882	5.335	58.274	Visualize Results
Classic++ [6]	9.959	5.410	47.000	8.072	5.554	3.750	1.403	5.098	64.135	Visualize Results
Classic+NL-fast [7]	10.088	5.659	46.145	8.010	5.738	4.160	1.092	4.666	67.801	Visualize Results
AnisoHuber.L1 [8]	11.927	7.323	49.366	9.464	7.692	5.929	1.155	7.966	74.796	Visualize Results


MDP-Flow2 estimated flow
MDP-Flow2 EPE


Groundtruth


MDP-Flow2 EPE

Middlebury avg **EPE**: 0.245 **px**

Sintel avg **EPE**: 8.445 **px**

Evaluation Take-aways

- Much larger errors than Middlebury (~35x)
- Unmatched regions are really hard
  ~45px error (vs. ~5px in matched regions)
- High speeds (>40 ppf) much worse than low speeds (<10 ppf)
  ~50px error vs. ~1.5px error
- Final pass harder than the Clean pass (15-40% greater error)

Lessons learned

- We thought this would be easy – it wasn’t
- Movies just need to look good enough
- Full control of graphics data and rendering pipeline was necessary to create image sequences with accurate optical flow

See our poster at the Workshop on Unsolved Problems in Optical Flow and Stereo Estimation

Tomorrow at 2pm

Location: Adua 1F, Affari

Grand challenges for optical flow

1. Unmatched regions
   - Will encourage new methods that integrate information over time and incorporate layering

2. High speeds (>40px per frame)
   - Lookalikes exhibit these regions as well

3. Motion blur, defocus blur, atmospheric effects
   - Real world effects cause problems for current methods

http://sintel.is.tue.mpg.de

MJB and GBS were supported in part by NSF CRCNS Grant IIS-0904630.